EARLY PERCUTANEOUS TRACHEOSTOMY AFTER MEDIAN STERNOTOMY

Christian Byhahn, MD[a]
Thorsten Rinne, MD[b]
Stephan Halbig, MD[a]
Sabine Albert, MD[c]
Hans J. Wilke, MD[a]
Volker Lischke, MD, PhD[a]
Klaus Westphal, MD, PhD[a]

Objective: Tracheostomy offers significant advantages over endotracheal intubation in patients requiring long-term assisted ventilation. However, in patients who have undergone median sternotomy, it is believed that the danger of microbial contamination and consecutive infection of the sternal wound with microbes from the tracheostomy is high when conventional tracheostomy is performed. In contrast, percutaneous techniques are less likely to result in tracheostomy infection and thus bacterial contamination of neighboring structures. Nonetheless, to date there has been no prospective study confirming or disproving this assumption. Our study evaluated outcome after percutaneous tracheostomy in patients with a median sternotomy.

Methods: A total of 144 cardiac surgical patients had elective percutaneous tracheostomy at the bedside until postoperative day 14, with 4 different techniques. Systematic microbiologic monitoring of the sternal and tracheal wounds was used.

Results: In 13 patients sternal wound infection was suspected, but was confirmed in only 4 (2.8%) patients who actually showed microbial contamination of the sternum. In 2 of these patients, the identified microbes were not identical to those cultured from the trachea. The other 2 patients had sternal and tracheal cultures positive for methicillin-resistant *Staphylococcus aureus*. Cross-contamination of the sternotomy with microbes from the patient's airways was therefore ruled out. No patient had clinical signs of tracheostomy infection. Likewise, there were no cases of mediastinitis.

Conclusions: On the basis of our data, we conclude that cross-contamination of the sternal wound with microbes from the trachea is not a problem. Elective percutaneous tracheostomy is safe, even if performed during the first 14 days after median sternotomy. (J Thorac Cardiovasc Surg 2000;120:329-34)

Elective tracheostomy of patients requiring long-term assisted ventilation is an established treatment modality in intensive care medicine. In the era before the introduction of percutaneous techniques, conventional tracheostomy was performed to gain long-term airway access. In patients who had undergone previous median sternotomy, thoracic surgeons were concerned about cross-contamination of the tracheostomy and sternotomy wounds. The assumption was that the close proximity of sternal wound and tracheostomy leads to contamination of the sternotomy with bacteria from the airways, resulting in sternal infections or mediastinitis. Brown and coworkers[1] demonstrated a significant relationship between tracheostomy and sternal wound dehiscence or infection and therefore recommended avoidance of tracheostomy at least until the tissue planes had healed. In contrast, Marshall[2] reported on 140 patients who had conventional tracheostomy after heart operations without a single case of sternal wound infection. However, the discussion of whether tracheostomy should be performed before the median sternotomy had healed remained controversial. Pierce and

From the Department of Anesthesiology, Intensive Care Medicine and Pain Control,[a] Department of Thoracic and Cardiovascular Surgery,[b] and Department of Medical Microbiology,[c] J.W. Goethe-University Hospital Center, Frankfurt, Germany.

Received for publication Nov 16, 1999; revisions requested Feb 18, 2000; revisions received March 21, 2000; accepted for publication April 21, 2000.

Address for reprints: Christian Byhahn, MD, Department of Anesthesiology, Intensive Care Medicine and Pain Control, J.W. Goethe-University Hospital Center, Theodor-Stern-Kai 7, D-60590 Frankfurt, Germany (E-mail: c.byhahn@em.uni-frankfurt.de).

0022-5223/2000 $12.00 + 0 **12/1/108161**
doi:10.1067/mtc.2000.108161

Table I. *Surgical interventions and indications for elective tracheostomy in patients who underwent median sternotomy*

	TLT (n = 56)	*PDT (n = 42)*	*GWDF (n = 34)*	*CBR (n = 12)*	*Total (n = 144)*
Interventions					
Coronary artery bypass grafting	31	29	27	7	94
Coronary artery bypass grafting and valve repair or replacement*	13	5	0	1	19
Valve repair or replacement	5	2	5	2	14
Other	7	6	2	2	17
Indications for tracheostomy					
Respiratory insufficiency	17	15	10	8	50
Sepsis	11	12	6	1	30
Low cardiac output	11	9	7	2	29
Severe illness polyneuropathy†	1	0	4	0	5
Multiorgan failure	3	1	2	0	6
Cerebral disorders	13	5	5	1	24

TLT, Translaryngeal tracheostomy; *PDT,* percutaneous dilatational tracheostomy; *GWDF,* guide wire dilating forceps; *CBR,* Ciaglia blue rhino.
*$P = .04$.
†$P = .02$.

coworkers[3] recommended performance of cricothyroid tracheostomy to effectively isolate the tracheostomy from the sternotomy and to seal the sternal wound until postoperative day 14. In the 1990s, Hübner and coworkers[4] presumed that the risk of postoperative mediastinitis in most departments still leads to a hesitant indication for tracheostomy within the first 2 postoperative weeks.

Regardless of the fact that the pros and cons of tracheostomy after median sternotomy are still being discussed, to date there are no studies with a large number of patients and appropriate microbiologic testing proving the hypothesis that early tracheostomy results in an increased risk of sternal wound infections or mediastinitis.

Our study sought to determine whether percutaneous tracheostomy within the first 14 days after median sternotomy can be considered safe and free from postoperative infectious complications. Therefore, a total of 144 patients receiving tracheostomies with microbiologic testing, using 4 different percutaneous tracheostomy techniques, were studied.

Patients and methods

During a 41-month period, a total of 144 consecutive patients who had undergone median sternotomy because of cardiac operations at our institution and who received elective percutaneous tracheostomy within the first 14 postoperative days were included in the study after informed consent was obtained from their relatives. Tracheostomies were performed when the patients were not expected to be extubated within the following 10 days.

All tracheostomies were performed after achievement of general intravenous anesthesia by the same team at the patient's bedside in the intensive care unit (ICU) by means of pressure-controlled ventilation. The inspired oxygen fraction was set to 1.0 ten minutes before the procedure was started. Intraoperative monitoring consisted of continuous electrocardiography, an indwelling arterial line, and pulse oximetry. In every instance tracheostomy was done under fiberbronchoscopic control, either according to Ciaglia's (percutaneous dilatational tracheostomy [PDT], n = 42, or Ciaglia blue rhino [CBR], n = 12), Griggs' (guide wire dilating forceps [GWDF], n = 34), or Fantoni's (translaryngeal tracheostomy [TLT], n = 56) techniques, all of which have been described elsewhere.[5-8] The choice of procedure was made by the surgeon, depending on a number of individual factors, such as the degree of respiratory insufficiency or coagulopathy. Strict contraindications for percutaneous tracheostomy were difficult cervical anatomy with unidentifiable anatomic landmarks, known or expected difficult endotracheal intubation, and visible large blood vessels in the operative field. If contraindications applied, these patients were scheduled to undergo conventional surgical tracheostomy. Finally, all patients underwent bronchoscopy after completion of percutaneous tracheostomy to suction blood or saliva from the trachea if necessary.

On the morning before tracheostomy, as well as 2 days after the procedure, tracheal secretions were obtained and cultured for bacteria and fungi. Cultures from the sternotomy wound were obtained only if there were clinical signs of infection of the wound, which was checked at least once every day. Likewise, the tracheostomy wound was inspected daily, and cultures were obtained only when infection was suspected.

All tracheal cultures underwent complete microbiologic analysis. Likewise, all cultures from the sternotomy wound obtained on every second day within a week before and a week after tracheostomy were compared with the tracheal cultures of the individual patients. In this way we sought to detect cross-contamination of the sternal and tracheal wounds.

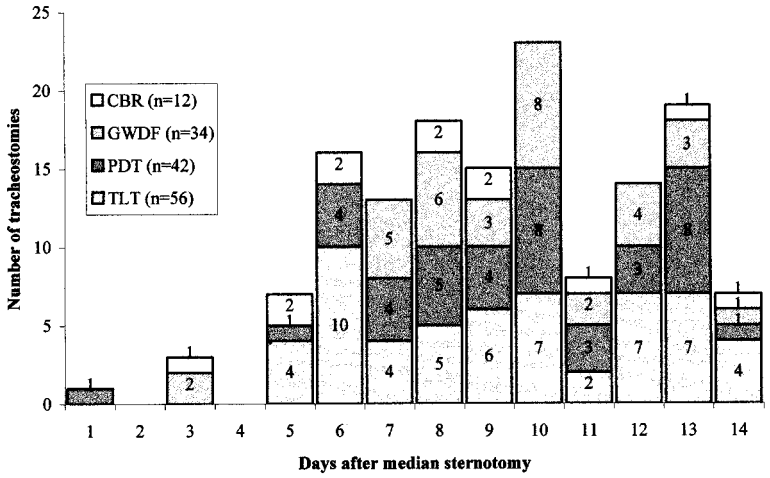

Fig 1. Time period between median sternotomy and percutaneous tracheostomy in 144 patients who underwent cardiac surgery. *CBR,* Ciaglia blue rhino; *GWDF,* guide wire dilating forceps; *PDT,* percutaneous dilatational tracheostomy; *TLT,* translaryngeal tracheostomy.

Once the homogeneity of the data was confirmed, 1-way analysis of variance was used to compare the raw data in terms of means and SD, whereas the Fisher exact test and the χ^2 test for independence were used to compare contingencies. All statistical calculations were performed by means of GraphPad InStat Version 3.00 software (GraphPad Software, Inc, San Diego, Calif).

Results

A total of 144 cardiac surgical patients (76 male and 68 female patients) with a median sternotomy who were in the ICU received elective percutaneous tracheostomy up to postoperative day 14 because of the need for long-term assisted ventilation. Until tracheostomy, all patients had either oral or nasal endotracheal tubes. All tracheostomies were performed at the patient's bedside in the ICU. The TLT (n = 56), PDT (n = 42), GWDF (n = 34), and CBR (n = 12) tracheostomy techniques were used. Types of cardiac procedures and indications for long-term ventilation and thus tracheostomy are listed in Table I.

Tracheostomy was performed on day 9 (median value) after median sternotomy. With regard to the different techniques, tracheostomy timing was similar ($P > .2$). Fig 1 shows the number of the various technical procedures, as well as the day of tracheostomy. Forty (27.8%) of the patients had tracheostomies within the first week after median sternotomy, whereas 104 (72.2%) received percutaneous tracheostomy within the second postoperative week. No patient underwent open tracheostomy because of contraindications for percutaneous techniques.

In 103 (before tracheostomy) and 92 patients (after tracheostomy), tracheal cultures were positive for bacteria, fungi, or both. Between the different patient groups, there were no statistically significant differences with regard to the number of positive tracheal cultures both before and after tracheostomy ($P > .2$). Likewise, preoperative and postoperative prevalence for positive cultures was similar within a given group ($P > .2$). Bacteria that were detected were either apathogenic and thus did not require antibiotic treatment or received adequate antibiotic coverage in case of pathogenicity (Table II).

A total of 13 (9.0%) patients showed clinical signs of an infected sternal wound within the first week before and after tracheostomy. Two of these patients had received tracheostomy according to the Fantoni technique (TLT) while they still had an open thorax. In 4 (2.8%) patients sternal cultures were positive for bacteria or fungi, which was considered proof of infection. In 1 patient, sternal culture on the first day after TLT was positive for *Enterococcus faecalis,* whereas the tracheal culture showed *Acinetobacter* species. The postoperative tracheal cultures had been negative. In the PDT group there was also a positive sternal culture, namely, *Candida albicans*. However, both tracheal cultures were negative for bacteria and fungi. Two patients from the GWDF group showed contamination of the sternotomy wound with methicillin-resistant *Staphylococcus aureus* both before and after tracheostomy. Methicillin-resistant *S aureus* was also found in both tracheal cultures of these patients.

Table II. *Results of microbiologic cultures from tracheal secretions of patients who had percutaneous tracheostomy after median sternotomy*

	TLT (n = 56)		*PDT (n = 42)*		*GWDF (n = 34)*		*CBR (n = 12)*		*Total (n = 144)*	
	Before	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*	*Before*	*After*
Patients with negative results	18	18	13	19	6	8	4	7	41	52
Patients with positive results	38	38	29	23	28	26	8	5	103	92

TLT, translaryngeal tracheostomy; *PDT,* percutaneous dilatational tracheostomy; *GWDF,* guide wire dilating forceps; *CBR,* Ciaglia blue rhino.

In 9 of the patients with clinical signs of sternal wound infection, including 2 patients with an open thorax, sternal cultures tested negative. Therefore, sternal wound infection was ruled out. Nonetheless, all of these patients had positive tracheal cultures with bacteria, such as *Haemophilus influenzae*, *Pseudomonas aeruginosa*, or *Klebsiella pneumoniae*. Regardless of the technique chosen for tracheostomy, no patient showed clinical signs of infection of the tracheostomy wound. Likewise, there was no case of mediastinitis.

The risk of complications during tracheostomy was low. In 4 patients complications occurred that required instant intervention, namely, major bleeding in 2 patients who had either PDT or GWDF. In 1 patient of the TLT group, pretracheal insertion of the tracheostomy tube was detected bronchoscopically. After rapid reintubation, uneventful PDT was performed. Furthermore, mediastinal emphysema occurred a few hours after uneventful GWDF but resolved spontaneously within the next 72 hours. All complications could be managed without difficulties by the team that had performed the tracheostomy.

Discussion

Tracheostomy is one of the oldest procedures in the history of surgery and is often indicated when there is a need for prolonged mechanical ventilation. In comparison with oral or nasal endotracheal intubation, tracheostomy facilitates airway toilet and weaning from the ventilator. Enteral feeding can be restarted earlier, and the procedure is well tolerated by the patients and accepted by the nursing staff.[9,10] However, the controversy with regard to the optimal timing of tracheostomy is still unresolved. In 1989, the Consensus Conference on Artificial Airways recommended that elective tracheostomy be performed early between days 3 and 5 if weaning from the respirator could not be foreseen within the next 21 days. If the period of expected intubation could not be determined, the pros and cons of tracheostomy should be evaluated on a daily basis.[11] Several studies have shown that the critical period for the development of laryngotracheal lesions caused by the endotracheal tube is between the seventh and eleventh days of intubation and maybe earlier.[12-14] As a consequence, many authors recommend that an elective tracheostomy be performed after about day 10 of intubation.[15-17]

Before percutaneous tracheostomy became popular with the introduction of PDT in 1985,[5] conventional tracheostomy was performed for long-term airway control. A number of studies demonstrated that severe tracheostomy wound infection, defined as peristomal cellulitis, skin necrosis, skin breakdown or purulent secretions at the stoma, or peristomal infection that necessitates antibiotic coverage, is a frequent complication of the conventional technique and occurs in 17% to 36% of patients.[16,18-20] Particularly in proximity to a sternotomy wound, purulent secretions are a cause for concern. A significant relationship between conventional tracheostomy and major sternal wound dehiscence or infection has been reported by Brown and coworkers,[1] who reviewed the case histories of 748 patients who had cardiac operations. By way of minimizing the risk of sternal wound contamination from the tracheostomy, sophisticated sternal wound dressings were developed, presumably eliminating or reducing the risk of wound infection and mediastinitis in patients who underwent either tracheostomy before the sternotomy had healed or sternotomy while having a pre-existing tracheostomy.[3,21,22] Severe tracheostomy infections have been significantly less frequent with percutaneous tracheostomy than with conventional tracheostomy,[4,15,16,19,20,23-25] and only one study demonstrated that no wound infections occurred regardless of whether percutaneous or conventional tracheostomy was performed.[17] The question of whether percutaneous tracheostomy can be performed early after median sternotomy without exposing the patients to the risks of sternal wound infection or mediastinitis has not been answered to date by means of a study in a large number of patients and appropriate microbiologic testing.

The era of minimally invasive tracheostomy started in 1985 with the description and introduction of Ciaglia's PDT.[5] PDT became the most established technique, but the percutaneous techniques of Griggs (GWDF) and Fantoni (TLT) were shown to be equally safe and practicable.[6,7,23-25] Because the percutaneous tracheostomy techniques are cost-efficient, easily performed at the patient's bedside, and safe and virtually free of major complications, they are increasingly being used instead of surgical tracheostomy and have been established as a modern treatment modality in intensive care medicine.[26] In our study only 4 (2.8%) of 144 patients had perioperative complications, all of which were readily managed by the tracheostomy team and posed no major threat to the patients. A key element of percutaneous techniques is the fact that the tracheal cannula is positioned by dilation only. As a result, there is an extremely tight fit of the tracheal cannula because the elastic wound edges firmly adhere to the cannula. In consequence, contact of the tracheostomy with tracheal secretion is minimized, and infections are thus unlikely. Similarly, contamination of the cervical and thoracic regions with tracheal secretions is virtually impossible. This is very different in the case of conventional surgical tracheostomy, in which microbial contamination of both the tracheostomy itself and of the cervical and thoracic regions, including the sternal wound and mediastinum, seems much more likely.

To date, there is only one study of 45 patients who had early elective percutaneous tracheostomy according to Griggs' GWDF technique after a median sternotomy. Tracheostomy was performed on postoperative day 6 (median) and sometimes as early as on the second day after median sternotomy. There was not a single case of infection of the sternal wound. However, the study was based on clinical findings exclusively.[4] In comparison with our investigation, there was no microbial testing of both the tracheal secretions and the sternal wound. However, we also obtained sternal cultures only when daily inspection revealed clinical signs of wound infection, such as erythema or purulent secretion, either alone or in combination with fever, elevated white blood cell count, or elevated C-reactive protein. We could show that, at the time of tracheostomy, 71.5% of our patients had tracheal cultures positive for microbes, some of which were highly pathogenic and likely to cause sternal wound infections. Regardless of a high prevalence of airway contamination with microbes, sternotomy infection was suspected in only 13 (9.0%) patients on the basis of clinical findings, and pathogenic microbes that actually confirmed wound infection were found in the sternal swabs of only 4 (2.8%) patients. In 2 of these patients, we were able to demonstrate that the types of microbes from the sternal wound were not identical with the ones from the airways. Hence, cross-contamination could be ruled out. Although in the 2 other patients methicillin-resistant *S aureus* was cultured from both the sternal wound and the tracheal secretions, both patients had positive test results for methicillin-resistant *S aureus* before tracheostomy. Again, cross-contamination could be excluded. In the remaining 9 patients whose sternal cultures tested negative and therefore could have sternal wound infection ruled out, pathogenic microbes were found in their airways. Furthermore, 2 patients who underwent tracheostomy according to the Fantoni technique while having an open thorax had sternal cultures negative for both bacteria and fungi. It bears emphasis that not a single patient had clinical signs of tracheostomy infection at daily inspection.

Our results demonstrate clearly that percutaneous tracheostomy regardless of the technique is safe, even if performed during the first 2 weeks after median sternotomy. There was no contamination of the sternal or mediastinal regions with microbes from the airways. In addition, the incidence of perioperative complications was only 2.8%. Thus, percutaneous techniques are safe with regard to microbiologic considerations. For all these reasons, we strongly believe that cardiac surgical patients on long-term mechanical ventilation should no longer be denied the benefits of early percutaneous tracheostomy.

We thank Hanns Ackermann, PhD, for statistical advice and review.

REFERENCES

1. Brown AH, Braimbridge MV, Panagopoulus P, Sabar EF. The complications of median sternotomy. J Thorac Cardiovasc Surg 1969;58:189-97.
2. Marshall RD. A review of the management of 140 elective tracheostomies following open heart surgery. Thorax 1969;24:78-83.
3. Pierce WS, Tyers GFO, Waldhausen JA. Effective isolation of a tracheostomy from a median sternotomy wound. J Thorac Cardiovasc Surg 1973;66:841-2.
4. Hübner N, Rees W, Böckelmann M, Christmann U, Warnecke H. Percutaneous dilatational tracheostomy done early after cardiac surgery: outcome and incidence of mediastinitis. Thorac Cardiovasc Surg 1998;46:89-92.
5. Ciaglia P, Firsching R, Syniec C. Elective percutaneous dilatational tracheostomy: a new simple bedside procedure; preliminary report. Chest 1985;87:715-9.
6. Griggs WM, Worthley LIG, Gilligan JE, Thomas PD, Myburgh JA. A simple percutaneous tracheostomy technique. Surg Gynecol Obstet 1990;170:543-5.

7. Fantoni A, Ripamonti D. A non-derivative, non-surgical tracheostomy: the translaryngeal method. Intensive Care Med 1997;23:386-92.
8. Byhahn C, Lischke V, Halbig S, Scheifler G, Westphal K. Ciaglia Blue Rhino: a modified technique for percutaneous dilatational tracheostomy—technique and early results. Anaesthetist 2000;49:202-6.
9. Heffner JE, Miller KS, Sahn SA. Tracheostomy in the intensive care unit. Part 1: Indications, technique, management. Chest 1986;90:269-74.
10. Rodriguez JL, Steinberg SM, Luchetti FA, Gibbons KJ, Taheri A, Flint LM. Early tracheostomy for primary airway control in the surgical critical care setting. Surgery 1990;108:655-9.
11. Plummer AL, Gracey DR. Consensus conference on artificial airways in patients receiving mechanical ventilation. Chest 1989;96:176-80.
12. Whited RE. A prospective study of laryngotracheal sequelae in long-term intubation. Laryngoscope 1984;94:367-77.
13. Bishop MJ. Mechanisms of laryngotracheal injury following prolonged tracheal intubation. Chest 1989;96:185-6.
14. Bishop MJ, Hibbard AJ, Fink BR, Vogel AM, Weymuller EA. Laryngeal injury in a dog model of prolonged endotracheal intubation. Anesthesiology 1985;62:770-3.
15. Graham JS, Mulloy RH, Sutherland FR, Rose S. Percutaneous versus open tracheostomy: a retrospective cohort outcome study. J Trauma 1996;42:245-50.
16. Holdgaard HO, Pedersen J, Jensen RH, Outzen KE, Midtgaard T, Johansen LV, et al. Percutaneous dilatational tracheostomy versus conventional surgical tracheostomy. Acta Anaesthesiol Scand 1998;42:545-50.
17. Porter JM, Ivatury RR. Preferred route of tracheostomy—percutaneous versus open at the bedside: a randomized, prospective study in the surgical intensive care unit. Am Surg 1999;65:142-6.
18. Stauffer JL, Olson DE, Petty TL. Complications and consequences of endotracheal intubation and tracheostomy: a prospective study of 150 critically ill adult patients. Am J Med 1981;70:65-76.
19. Hazard P, Jones C, Benitone J. Comparative clinical trial of standard operative tracheostomy with percutaneous tracheostomy. Crit Care Med 1991;19:1018-24.
20. Stoeckli SJ, Breitbach T, Schmid S. A clinical and histological comparison of percutaneous dilational versus conventional surgical tracheostomy. Laryngoscope 1997;107:1643-6.
21. Kaiser LR, Salerno TA. Coronary artery bypass in patients with total laryngectomy. Ann Thorac Surg 1985;39:481-2.
22. Nataf P, Regan M, Cantoni E, Bonnet N, Gandjbakhch I. Video-assisted coronary artery bypass in patients with preexisting tracheostomy. Ann Thorac Surg 1999;67:1153-4.
23. Westphal K, Lohrengel A, Wilke HJ, Rinne T, Wichelhaus TA, Lischke V. Percutaneous dilatational tracheostomy in a cardiac-surgical ICU. Z Herz Thorax Gefäßchir 1998;12:177-81.
24. Walz MK, Peitgen K. Percutaneous dilatational tracheostomy versus translaryngeal tracheostomy—a prospective randomized trial in 50 critically ill patients. Chirurgie 1998;69:418-22.
25. van Heerbeek N, Fikkers BG, van den Hoogen FJA, Mollen RMHG, Marres HAM. The guide wire dilating forceps technique of percutaneous tracheostomy. Am J Surg 1999;177:311-5.
26. Simpson TP, Day CJE, Jewkes CF, Manara AR. The impact of percutaneous tracheostomy on intensive care unit practice and training. Anaesthesia 1999;54:186-9.